معمل هندسة الإتصالات

تانية إتصالات

ترم ثاني

2013 _ 2014

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Exp ①: VCO

- **What is a VCO ?**

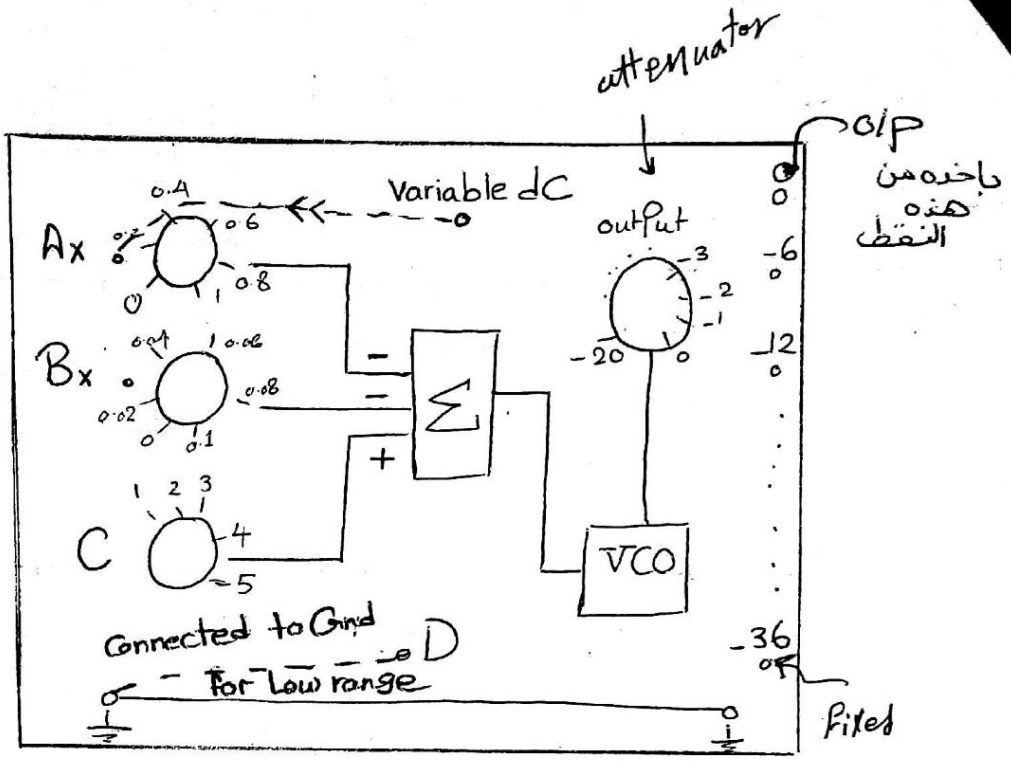
A Voltage Controlled Oscillator is a circuit that Produces [Square wave] whose frequency depends on the i/p voltage.
Changing i/p voltage change o/p frequency.

- **Applications:**

* Function generator (to get a range of different frequencies by adjusting a rotator).
* PLL (Phase-Locked loop)
* Frequency Synthesizers (a circuit that can be used to generate a range of freq
* AM modulation (used to [generate the Carrier], it is common that the Carrier is Sinusoidal with a single frequency, a Sin Signal can be extracted from the Square using a Filter centered around fo which is the Square fundamental frequency) "our objective now" $f_c \simeq 465\,KHz$
* FM modulator (the VCO achieves the concept of FM as the o/p signal freq. can change with the change in the input [message signal amplitude].

. module وكل 2950 Electronic Comm. Trainer عليها الـ modules المستخدمة موجودة في حقيبة .

2900 Function generator / Power Supply وهو متوافق مع 2950 A هو VCO الـ عليه حرف مثلاً



- The o/p Square has Amplitude, frequency.

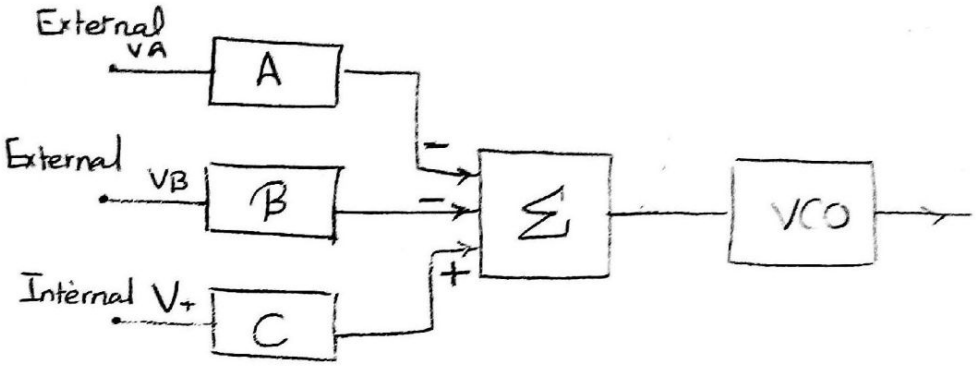
- How to Control Amplitude?
  - * Variable attenuator Knob
  - * Fixed o/p attenuator Sockets

    Total att. = Fixed + Variable

- How to Control frequency?
  - * D → Ground : Low range ≃ (1KHz ⇒ 5KHz) (C=1 to C=5)
    → open : high range ≃ (100 KHz ⇒ 1 MHz)

* Internal → using C Knob [متغيرة بوجود ثابت داخلياً]
  . there's a Potentiometer beside C with different settings that acts as a multiplier to Control C voltage ratio

* External → Ax: V_A X (0 → 1) Coarse changes
  Bx: V_B X (0 → 0.1) Fine changes



$V_C \uparrow$ $f \uparrow$ لأن إشارة الجهد موجبة

$V_A, V_B \uparrow$ $f \downarrow$ سالبة " " "

Practice 1.1. :- Calibration of VCO

- A, B, ~~not Connected~~, variable attenuator = 0
- only change C knob.

Change C, observe f

C	(1) Low range ⊠ Gnd f	(2) High range ⊡ Open f
1	≃ 1KHz	
2	≃ 2 KHz	
3		
4	⋮	
5	≃ 5 KHz	1. MHz

Practice 1.2 :- Use of external freq. Control Pins

1. * D Ground (Low range) — C ثبت, change A_x or B_x, observe F
   * adjust C for 5 KHz
   * adjust Power Supply to +4 V.
   * Connect variable dc socket to A_x.
   * Try A = 1 and watch F ↑ or ↓ = ??? علاقة عكسية
     A = 0.5
     :
   * Do the Same with B
2. * Repeat for D un connected (ungrounded).

لا داعي لجدوله

Practice 1.3 :- Attenuator

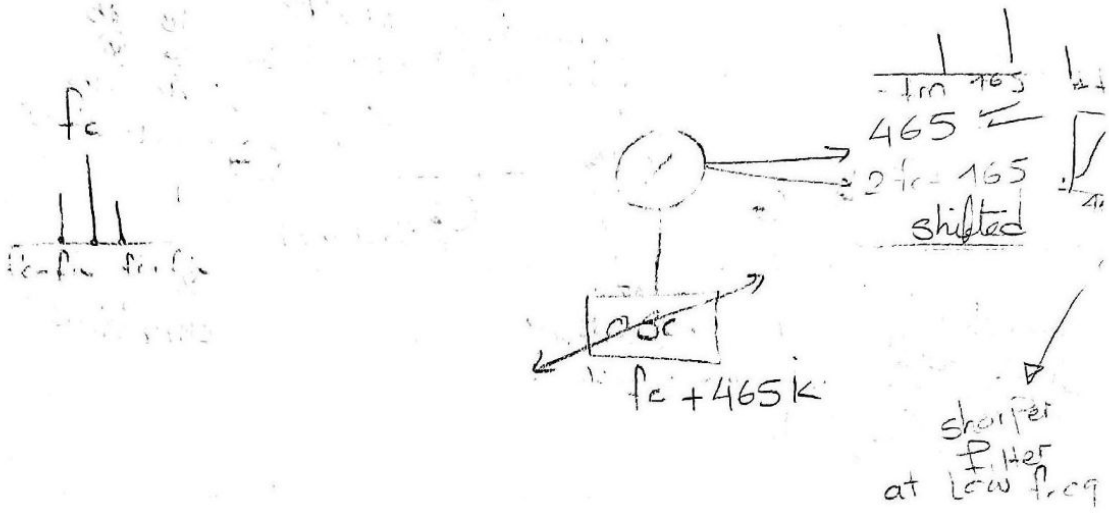
هنثبت الـ F ونلاحظ الـ attenuation (ثبت C)

* A, B, D not Connected
* Set C into dot (AM freq. تنزل) or a certain level.

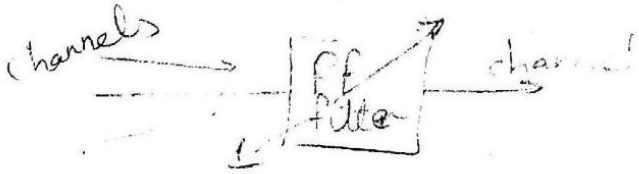
Atten.	V_o o/p p-p	$\frac{V_o}{V_{in}}$	$20 \log \frac{V_o}{V_{in}}$
0	V_{in} = 1.6 v p for any f	1	0
-3		<1	-3
-6			
-9			
:			
-36			

- VCO is a relaxation osc. made by IC 566 that has Square & tri o/p but

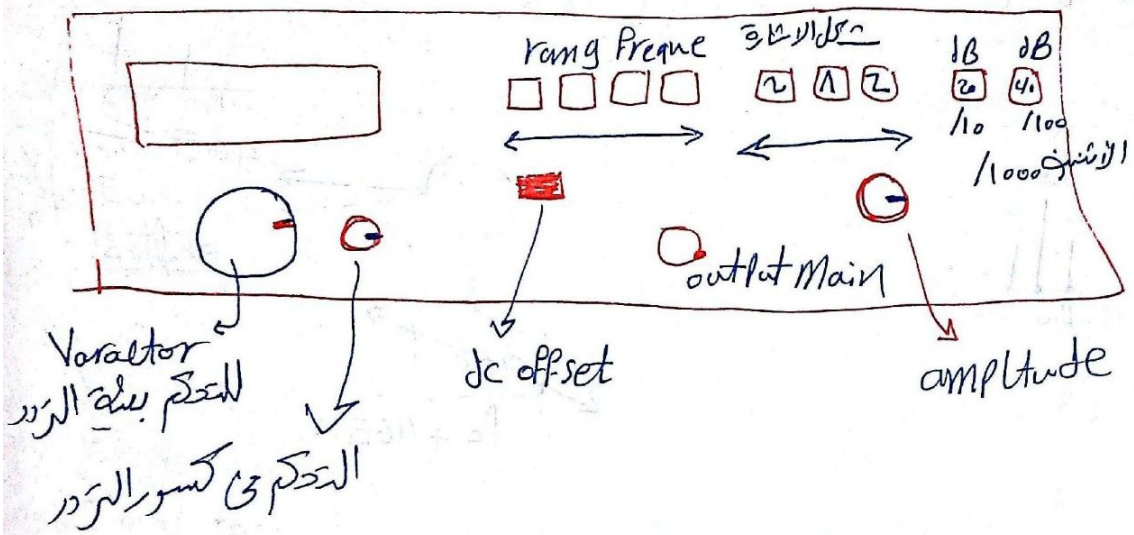
في الـ Super heterodyne Rx التحكم بيكون في oscillator وليس في الـ filter
حيث أنه ثابت عند 465 K وهو سهل عملياً أن يكون الـ osc هو المتغير variable
وليس الـ filter كما أن تصميم الدائرة يكون أبسط مع الترددات الأقل



old



Function generator



Close my eyes only for
a moment, and the moment's gone

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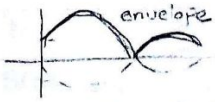
Exp ③: Full AM
(modulation and demodulation)

- In analog systems, PM is not available but PSK in digital systems is available.

- AM radio → $f_m = 5\ KHz$
  BW of channel = $2f_m = 10\ KHz$

- In Full AM → $P_c = \frac{2}{3} P_t$ which is wasted Power, the useful power is in the DSB.
  - BW = $2f_m$
  - easy to receive by envelope detector

- μ (modulation index) = $\frac{A_m}{A_c}$ → mathematically, $\mu = 1$ is accepted
  Practically, use $\mu = 0.7$ or 0.8

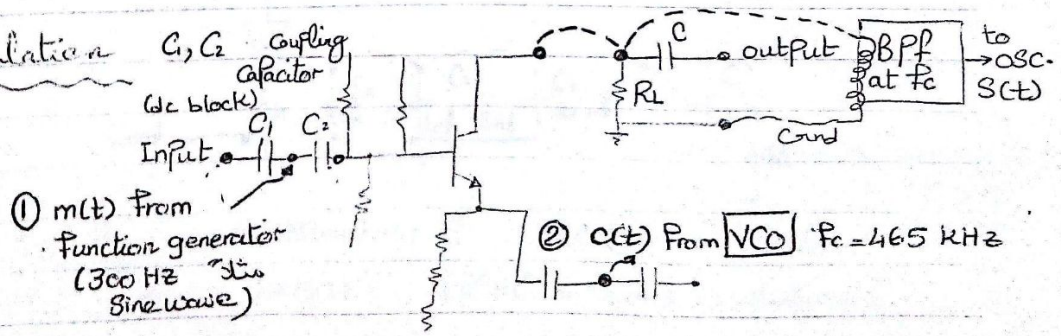


if $\mu > 1$ envelope doesn't represent m(t)

- $S(t) = A_c \cdot (1 + k_a m(t)) \cos(2\pi f_c t)$ or $c(t) \cdot (1 + k_a m(t))$

- We will use non-linear device for AM mod. (transistor)

① Modulation



Don't worry.
Be happy

$m(t) \rightarrow$ Base
$c(t) \rightarrow$ emitter
$S(t) \rightarrow$ Collector

$$I_c = I_s \cdot (e^{V_{BE}} - 1)$$

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \cdots \quad \text{(Maclaurin Series)}$$

$$I_c = C_0 + C_1 \cdot V_{BE} + C_2 \cdot V_{BE}^2 + C_3 \cdot V_{BE}^3 + \cdots$$

$M^2(f)$ at $2f_m$ ← $m^2(t) = A_m^2 \cos^2(2\pi f_m t)$

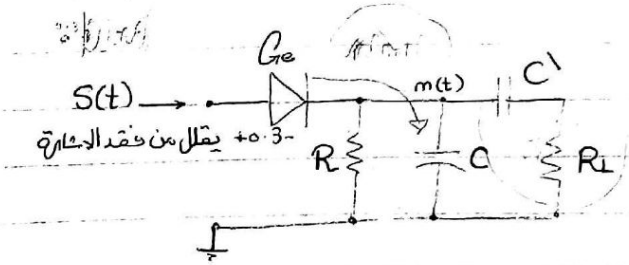
$$I_c = C_0 + C_1 (m(t) - c(t)) + C_2 (m^2 - 2mc + c^2) + \cdots$$

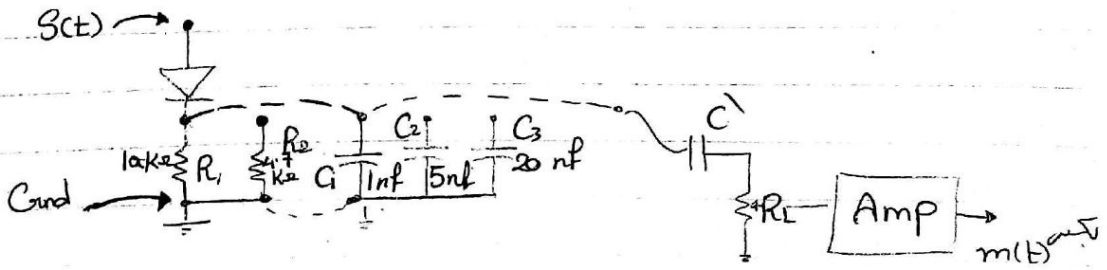
$$S(t) = c(t) + k_a \cdot m(t)\, c(t)$$

Carrier + message * Carrier

using BPF that is tuned at f_c we will pass the AM components.

(2) Demod:





R1 // R2 with smallest C RC ↓ ripples
f_c = 100 kΩ , largest C (C // C = Sum) diagonal

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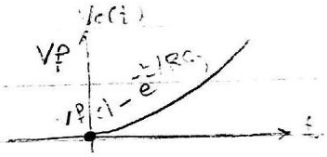
* Charging happens through R_s of the diode which is a very small resistance

$\therefore R_s \cdot C$ ↓↓ So charging happens fast which is required

Charging $V_c(t) = V_f \cdot (1 - e^{-t/RC})$

↳ final voltage or supply voltage



* discharging through RC which is designed such that it is suitable value because:

• if RC is very small → تفريغ سريع جدًا → Rf ripples

$V_c(t) = V_s \cdot e^{-t/RC}$

Try 4.7 kΩ and 1nf

or (4.7||10) kΩ and 1nf

3.19 kΩ

discharging $V_c = V_s \cdot e^{-t/RC}$

↳ supply voltage

• if RC is very large → diagonal distortion → تفريغ بطيء

$\frac{1}{f_c} \ll RC \ll \frac{1}{f_m}$ → optimum

$\frac{1}{465\,kHz} \ll 10\,k\Omega \cdot 1nf \ll \frac{1}{300}$

$2.15 \times 10^{-3} \ll 10^{-5} \ll 3.33 \times 10^{-3}$

What is −ve peak clipping?

due to $\grave{C}$ R_L part

at μ close to 1 → no over modulation

while o/p look like

زود ال Am لحد ما يحصل ال clipping

وأتأكد من هذا بأن ال μ لا يزال أقل من واحد عن طريق S(t)

$$c(t)\,(1 + k_a \cdot m(t))$$

I_{dc} → see only R because C o.c

I_{ac} → see $R \parallel R_L$

∴ I_{dc} sees different view than I_{ac}

In AM signal $I_{dc} < I_{ac}$

now → I_{dc} may not be less than I_{ac} & it happens when μ close to 1

$$\mu_i = \frac{I_m}{I_c} = \frac{I_{ac}}{I_{dc}} = \frac{A_m / R_{ac}}{A_c / R_{dc}}$$

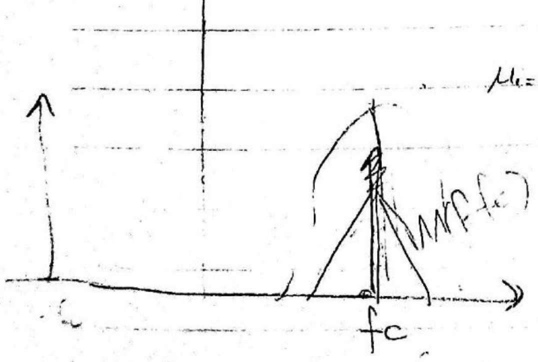
الطبيعي أنه بساوي $\frac{A_m}{A_c}$ لكن مع اضافة $\grave{C}$, R_L أصبح I_c (dc) يرى R فقط

بينما I_m (ac) يرى $R_L \parallel R$ وهي أصغر من R فلذلك زادت قيمة μ_i يعني I_m زادت

عن Am فلو تجاوز ال μ_i الواحد رغم عدم وصول ال μ إليه حدث −ve peak clipping

$$\mu = \frac{A_m}{A_c} = \frac{I_m}{I_c} = \frac{I_m / R}{I_c / R}$$

$$\mu_i = \frac{I_m / R_{ac}}{I_c / R_{dc}} = \frac{I_m}{I_c} \cdot \frac{R_{dc}}{R_{ac}} \qquad R_{ac} < R_{dc}$$



$= \frac{I_m}{I_c} \cdot$ [illegible]

Exp ⑤ FM modulation & demodulation

- In full AM (DSBTC), the B.W. of the AM signal was $2f_m$.

- In FM signals we have two types :

  ① NBFM (Narrow Band FM) → B.W. $= 2f_m$

  ② WBFM (Wide Band FM) → B.W. $= 2(\beta+1)f_m$
  $= 2(\Delta f + f_m)$

where $\beta = \frac{\Delta f}{f_m}$, $\Delta f = K_f \cdot A_m$

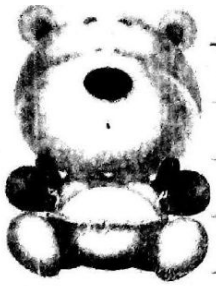
β ← Modulation index (مثل الـ m في الـ AM)

Δf ← Maximum frequency deviation
أقصى زيادة أو نقصان سيحدث في تردد الـ f_c بعد التعديل بواسطة الـ FM

- If $0 < \beta < 1$ → NBFM you will need only B.W. $= 2f_m$
  $\beta \geq 1$ → WBFM " " " " $= 2(\beta+1)f_m$

- What's the benefit of FM over AM system & what are the drawbacks? (عيوب)

In NBFM → Same AM B.W. which doesn't have benefit over AM in terms of less B.W. But as any FM signal it has high noise immunity because m(t) is carried in the frequency of the carrier not in its amplitude. So, as noise only affects the signal amplitude, m(t) will not be affected.



In WBFM → $B.W._{WBFM} > B.W_{AM}$ which is a drawback. but still it has noise immunity

$m(t)$ → Message Signal (Modulating Signal) الإشارة المُعدِّلة

$c(t)$ → Carrier Signal

$S(t)$ → Modulated Signal الإشارة بعد التعديل

$S(t) = A_c \cos(\theta_i(t))$ → f هو الـ Carrier عندما تتغير له

مع الزمن بالتالي θ متغيرة مع الزمن و $m(t)$ و $m(t)$

$$\theta_i(t) = \int_0^t \omega(t)\,dt$$ من تعريف الـ θ

$$= 2\pi \int_0^t f_i(t)\,dt$$

$f_i(t)$ التردد اللحظي وهو تردد الـ $c(t)$

$$= 2\pi \int_0^t f_c + k_f \cdot m(t)\,dt$$ زائد تغير التردد بـ $m(t)$

$$= 2\pi f_c t + 2\pi k_f \int_0^t m(t)\,dt$$

$$\therefore \boxed{S(t) = A_c \cos\left(2\pi f_c t + 2\pi k_f \int_0^t m(t)\,dt\right)}$$

$\cos u \xrightarrow{d/dt} -\sin u \cdot \frac{du}{dt}$

- $f_i(t) = f_c + k_f \cdot m(t)$

- At demodulation $m(t)$ لإسترجاع

$$\frac{d}{dt} S(t) = \underbrace{K \cdot \sin\left(2\pi f_c t + 2\pi k_f \int m(t)\,dt\right)}_{\text{FM}}$$

$$K \cdot A_c 2\pi f_c + A_c 2\pi k_f \cdot m(t) = 2\pi f_c \left(1 + \frac{k_f \cdot m(t)}{f_c}\right) \cdot A_c$$

⇓ AM

$$AM \longrightarrow S(t) = A_c\,(1 + k_a\, m(t))\cos(2\pi f_c t)$$

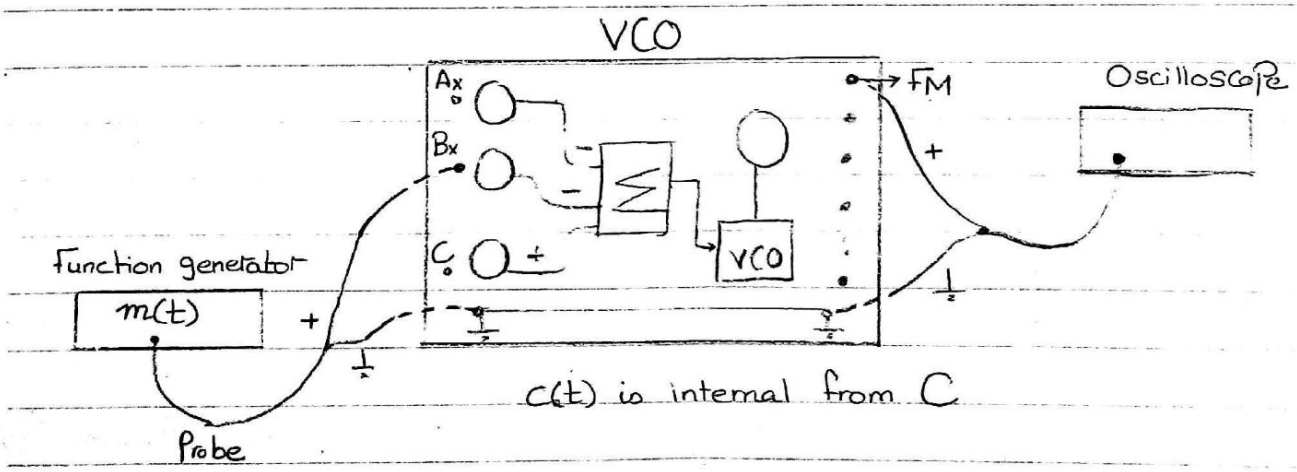
إذن المعادلة بعد التفاضل هي معادلة AM و FM معاً فنستطيع عمل detection لـ m(t) بواسطة AM demodulator مثل الـ envelope detector

$$f_i(t) = f_c + k_f \cdot m(t)$$

$$f_{i(t)_{max}} = f_c + |k_f \cdot m(t)|_{max} = f_c + |k_f \cdot A_m| \rightarrow = \Delta f$$

The Peak in case of sine, cosine tri, Squate

① Modulation



c(t) is internal from C

When you're down and troubled
And you need some love care

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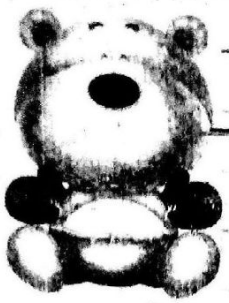


Steps :-

الفكرة هو ضبط الـ fc أولاً عن طريق C حتى تكون fc = 465 kHz
ثم عمل التوصيلة السابقة وإدخال الـ m(t) على Bx وبتعديل
الـ m(t) الجهد الداخل على الـ VCO تتغير التردد الخارج عن الـ fc.

وهو المطلوب ∴ $f_i(t) = f_c + K_f . m(t)$

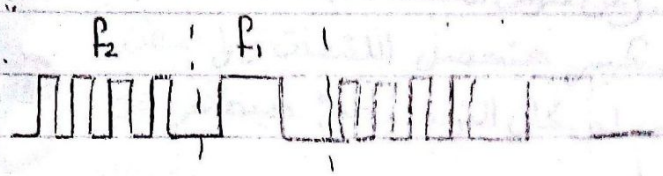
① Adjust C until fc = 465 kHz ; at this point you must not connect Bx.

② Connect m(t) from the fn. generator to Bx , choose m(t) Square wave , fm = 0.1 Hz

. For 0.1 Hz frequency → ① choose the least range on fn. generator (2 Hz)
② Choose least freq. from the range بتحريك الـ Knob لأقل قيمة وهاتكون حوالي 1 أو 2 Hz
③ Press the f÷10 button on the fn. generator

③ Let the Bx multiplier = 1 So you can see the effect of changing Am through changing the amplitude by the fn. generator only

Output :



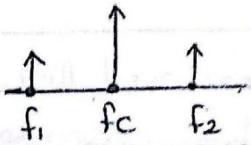
(لقطتين)

هام جداً :- ★ الإشارة الخارجة عبارة عن ترددين لأن الداخل هو Square به جهدين فقط ± Am .

$f_1 = f_c - K_f . A_m$ التردد المنخفض

$f_2 = f_c + K_f . A_m$ التردد العالي

$$\Delta F = K_f . A_m = \frac{f_2 - f_1}{2}$$



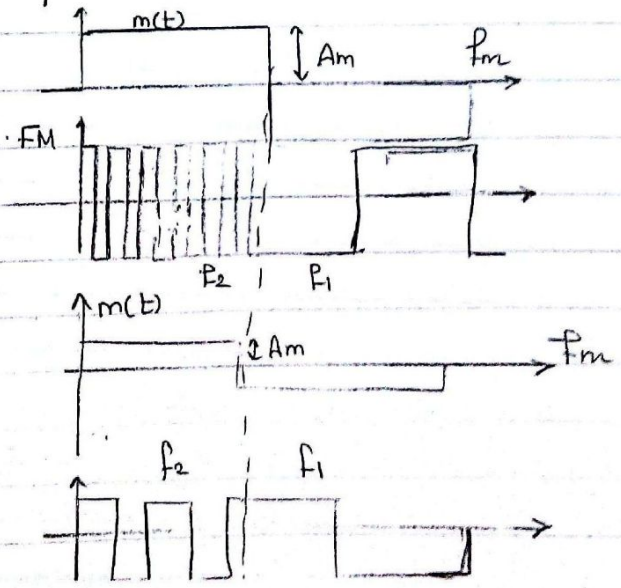
لقياس f_1 و f_2 على الـ analog osc. اضغط على $\frac{\Delta V}{\Delta t}$ مع أول ضغطه هيظهر خطين أفقين ضغطه تحان هيكونوا رأسيين ! المفروض نحدد زمن دوري باستخدام الخطين دول وذلك باختيار خط منهم ثم تحريكه يمين ويسار بالـ Knob حتى بداية T ثم اختار الخرب Select وحركه لنهاية T .

★ Study the effect of Am, fm.

$A_m \propto \Delta f$

Δf ⟵ تؤثر في الفرق بين اللقطتين يعني $(f_2 - f_1)$

هل التغير بين اللقطتين كبير أم أظهم متقاربين ؟



When you're down and troubled
And you need some love care

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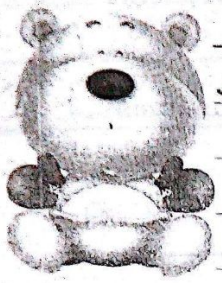


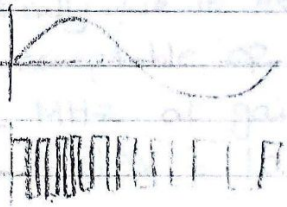
* f_m ← زمن عرض اللقطة

لما يكون التردد كبير هتحمل اللقطات ورا بعض بسرعة على عكس لو كان التردد بطئ هيظهر كل مشهد فترة أطول

. لو كل f_m كبير جداً ستظهر الإشارة ثابتة وبها الترددين فى نفس الوقت ودا لأنها تتغير فعلاً" لكن بشكل سريع جداً صعب ملاحظته.

الخرج

* If the i/p was sine or tri , the o/p will have more than 2 frequencies , it will have infinite frequencies and the freq. of the o/p will increase to a maximum then decrease.



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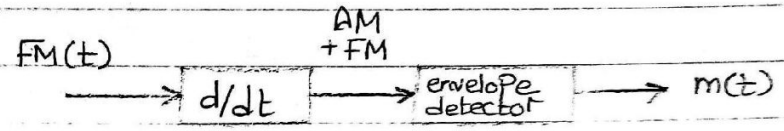
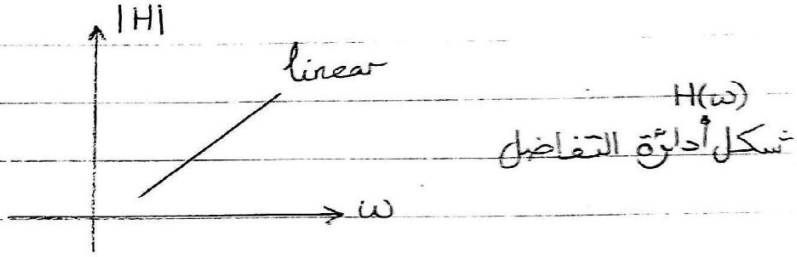
② Demodulation





شكل أداة التفاضل

* We used to differentiate signals by Op_amp circuit but this is not Practical in FM signals differentiation, Why ??

Because FM signals practically lie in the range (88 → 108) MHz which is out of the acceptable op_amp frequencies which has a maximum of 1 MHz. at gain = 1.

$$Gain * B.W = 10^6$$ ← قانون الـ opamp

d/dt →
- ① Slope detector
- ② Freq. discriminator (Round travise)
- ③ Fooster-Seely
- ④ Ratio detector

إحدى هذه الـ 4 دوائر قادرة على التفاضل و سنعمل على أول نوع الـ Slope detector .

When you're down and troubled
And you need some love care

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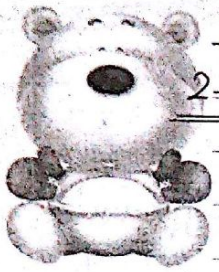
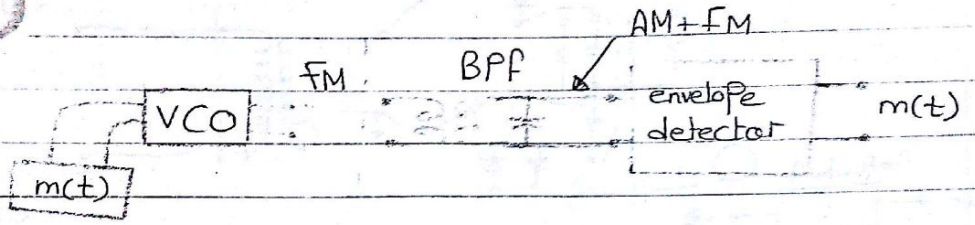
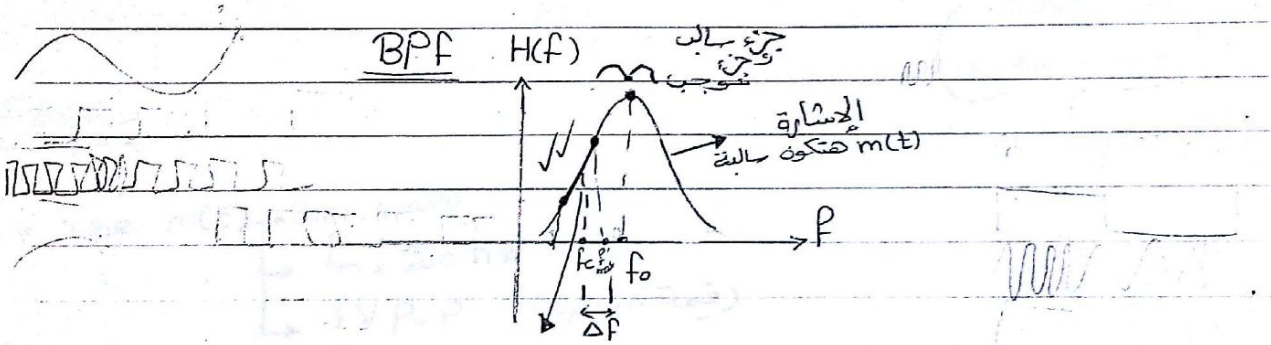


2-1- Slope detector

* It is a tuned circuit (BPf)

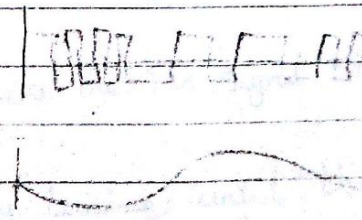


Modulator Demodulator



This is the Linear region we must work within because we need Linear response in differentiator circuits as Stated Previously.

* لماذا ستظهر m(t) سالبة في الجزء الأخر من المنحنى؟
لأن كل ما التردد هيزيد هيقل الـ amplitude (الميل سالب) وهذا عكس مبدأ عمل الـ FM أن كل ما كان m(t) تزيد ستزيد fi(t) بالتالي ستظهر الإشارة هنا معكوسة X سالب



. You must step away from fo .

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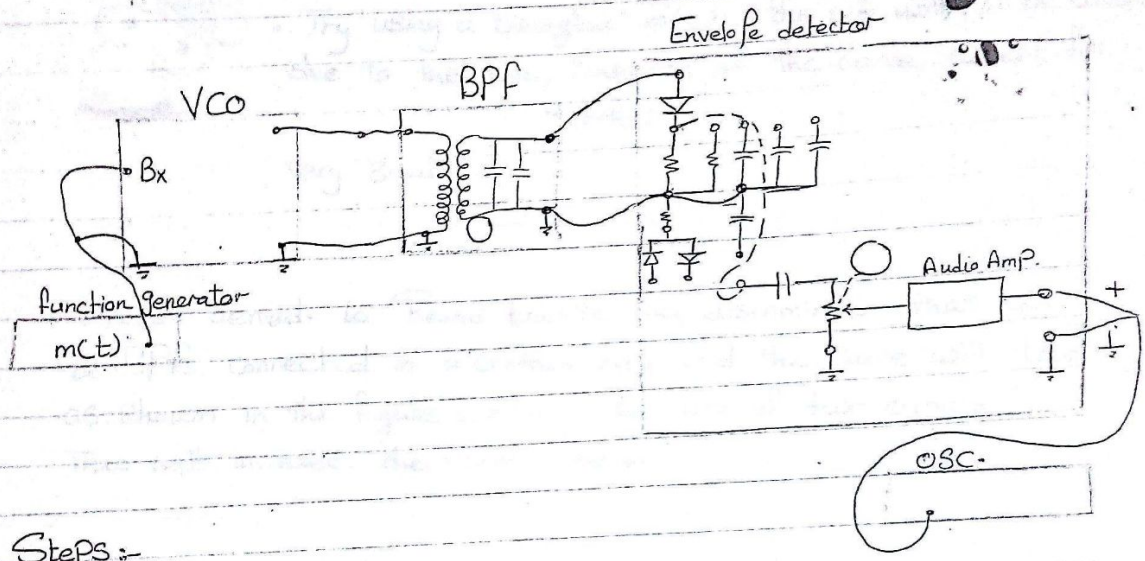

Steps :-

- Use m(t) → Sine wave
  - fm = 200 Hz
  - 1 V P-P (قيمة صغيرة)

- When displaying the o/p, the sine may be distorted so try to move away from fo by two things

① Adjust fo away by adjusting the knob in Bpf.

② decrease Δf by decreasing Am.

This will make the FM signal stay in the linear region of Bpf curve

- You can try tuning until the distorted ⟶ Sine appear when fc is at fo.

Don't worry.
Be happy

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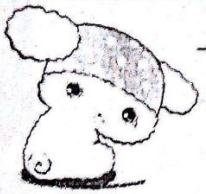
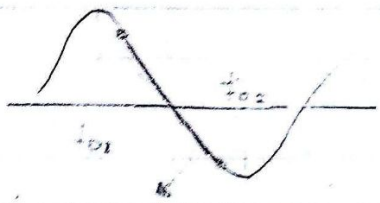
Date



• Try using a triangluar m(t), the o/p will not be linear due to the non-linearity of the curve except for very small Am.
Perfect

Another demod. is Round trasiise freq. discriminator that has 2 BPFs connected in a certain way and the curve will look as shown in the figure which is the Sum of two curves. This will increase the linear Region



linear

Notes

• تذكر دائماً أن يكون الـ Gnd واحد لكل الـ modules مع الـ osc. والـ fn. generator

• للتأكد أن الخارج هو إشارة وليس noise غير شكل الـ m(t) وراقب الشكل أمامك هل هيتغير أم لا ؟.